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PATENT APPLICATION

ATTORNEY DOCKET NO. 10001011-1

03/27/00 JC658 U.S. PTO

IN THE U.S. PATENT AND TRADEMARK OFFICE
Patent Application Transmittal Letter

ASSISTANT COMMISSIONER FOR PATENTS
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SIR:

JC564 U.S. PTO 09/535696 03/27/00

Transmitted herewith for filing under 37 CFR 1.53(b) is a(n): (X) Utility ( ) Design
(X) original patent application,
( ) continuation-in-part application

INVENTOR(S): **Scott A. Jones, Alan C. Berkema, Thang V. Le and Fred J. Anast**

TITLE: **METHOD AND SYSTEM FOR TRANSMITTING DATA BETWEEN A RECEIVER AND A TRANSMITTER**

Enclosed are:

(X) The Declaration and Power of Attorney. (X) signed ( ) unsigned or partially signed

(X) 4 sheets of drawings (one set) ( ) Associate Power of Attorney

( ) Form PTO-1449 ( ) Information Disclosure Statement and Form PTO-1449

( ) Priority document(s) ( )(Other) _____ (fee $_____)

CLAIMS AS FILED BY OTHER THAN A SMALL ENTITY				
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TOTAL CLAIMS	18 — 20	0	X $18	$ 0
INDEPENDENT CLAIMS	3 — 3	0	X $78	$ 0
ANY MULTIPLE DEPENDENT CLAIMS	0		$260	$ 0
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By Rachel Burke

Typed Name: **Rachel Burke**

Respectfully submitted,

Scott A. Jones, Alan C. Berkema,

By _____

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HP-1001011-1

09536268 032700

Inventors: Scott Jones; Alan Berkema; Thang Le; Fred Anast

METHOD AND SYSTEM FOR TRANSMITTING DATA BETWEEN A RECEIVER AND A TRANSMITTER

The present invention generally relates to a method and a system for transmitting data between at least one receiver operatively connected to at least one transmitter, and more particularly to a method and a system for permissible transmission via at least one high-speed link having a plurality of virtual channels.

Virtual channels are generally used for maximum efficiency usage of a single bi-directional serial link between a receiver and a transmitter. The communication is usually based on asynchronous concurrent processes at the packet level. More specifically, Communicating Sequential Processes ("CSP") is used for synchronized communication between the receiver and transmitter, meaning each communicating process waits until data transfer is complete before continuing.

One known method for maintaining the CSP while ensuring that no data is lost or overwritten suggests the use of acknowledgement packets. The receiver must acknowledge each packet before another can be sent, and all the packets of a message must also be acknowledged before the sending process continues. In this case, when the data packet is received by a process, an acknowledgement packet is sent back to the transmitter. The acknowledgement packet allows the transmitter to send another packet after a packet has been received or even partially received.

The problem with using acknowledgement packets is that the transmitter does not necessarily know if the receiver is ready to receive a packet in the first place. When the transmitter sends a packet to the receiver that does not have any available buffer, the packet is either lost or the link is flow controlled at the physical layer. If the packet is lost, the transmitter will never receive the acknowledgement packet. As a result, it must rely on some timer to know when to try again, causing delay and waste of bandwidth. On the other hand, if the data is flow controlled at the physical layer, data transmission is indefinitely postponed until the receiver is able to accept the data. Again, this causes both delay and waste of bandwidth by blocking other virtual channels.

Accordingly, it is an object of the present invention to provide an improved method and system for transmitting data using a virtual channel credit packet over a high-speed link with a plurality of virtual channels.

A related object of the present invention is to provide an improved method and system for transmitting data between a receiver and transmitter without the use of acknowledgement packets.

Another object of the present invention is to provide an improved method and system for allowing a transmitter to send a data packet to a receiver only after the receiver has resources to receive the packet.

Still another object of the present invention is to provide an improved method and system for transmitting data via at least one high-speed link with a plurality of virtual channels using more efficient bandwidth.

A further object of the present invention is to provide an improved method and system for transmitting data using a virtual channel credit packet having a unique assigned virtual channel number for each virtual channel.

BRIEF SUMMARY OF THE INVENTION

The present invention provides a method and a system for transmitting data between one or more receivers operatively connected to one or more transmitters, and more particularly to a method and a system for permissible transmission via at least one high-speed link having a plurality of virtual channels. By having the receiver send a credit packet with a unique virtual channel number that is specifically assigned to each virtual channel only when it has a buffer available, the present invention is able to bypass the need for an acknowledgement packet, resulting in reliable transmissions and efficient use of bandwidth.

In accordance with this invention, the receiver first sends a virtual channel credit packet for a particular virtual channel to the transmitter only if the receiver is available to receive data. A unique virtual channel number is assigned for that particular virtual channel, and is included in the virtual channel credit packet. Then, the transmitter responds to the virtual channel

credit packet accordingly, which includes transmitting data to the receiver if it is actually available. The receiver then receives the data packet transmitted from the transmitter. The sending of a credit packet guarantees that the receiver is ready and has the available resources to receive transmission data from the transmitter.

Other objects, features and advantages will become apparent upon reading the following detailed description, in conjunction with the attached drawings, in which:

FIGURE 1 is a schematic diagram of an exemplary connection between a peripheral and an I/O card in which the present invention may be implemented;

FIG. 2 is an ensemble illustrating the format and control characters for the data packet and the credit packet for one virtual channel;

FIG. 3 is a sequence illustrating the flow of the credit packet and the data packet for one virtual channel;

FIG. 4 is a flowchart illustrating the subroutine executed by the receiver; and,

FIG. 5 is a flowchart illustrating the subroutine executed by the transmitter.

DETAILED DESCRIPTION

Broadly stated, the present invention is directed to a method and a system for transmitting data between at least one receiver operatively connected to at least one transmitter over a high-speed link with a plurality of virtual channels. Each virtual channel is assigned with a unique virtual channel number. When the receiver is ready for transmission for a particular virtual

channel, it sends a virtual channel credit packet bearing the assigned virtual channel number. The transmitter then responds to the virtual channel credit packet. After the transmission for this particular virtual channel is finished, the process is repeated for the next virtual channel until all the virtual channels are running.

Turning now to FIG. 1, a schematic diagram of an exemplary connection between a peripheral device or peripheral and an I/O card is shown and illustrates one way in which the receiver is connected to the transmitter for the implementation of the present invention. However, it should be understood that other connections are possible and are within the scope of the present invention. In this example, a peripheral 10 is connected to an I/O card 12 through a bi-directional serial link 14 with a plurality of virtual channels 16. In this case, the peripheral 10 is the transmitter, and the I/O card 12 is the receiver. Although any number of virtual channels 16 can be used, 256 virtual channels are preferred for this implementation. The virtual channels can start from the number zero, and end with any desired number N as long as it is finite. The only limitation is the hardware. However, the number of virtual channels is important in that it determines the number of credit packets that will be used in the present invention, as will be described. Furthermore, the present method loops to repeat the process until all the virtual channels are running.

The preferred ensemble of a virtual channel data packet indicated generally at 20 and a credit packet indicated generally at 22 for one virtual channel is shown in detail in FIGs. 2 and 3. Each virtual channel is assigned a unique Virtual Channel Number (VCN) 24. As shown in FIG. 2, the packets include some of the control characters 26 defined by the Institute of Electrical and Electrics Engineers Standards (IEEE Std) 1355-1995 for Heterogeneous

Interconnect. In addition, the VCN 24 is used for both the data packet and the credit packet formats for each virtual channel. Because there is a number assigned for each virtual channel, the transmitter 10 and receiver 12 are able to keep track of the transmission within the plurality of virtual channels 16.

When the receiver 12 sends a virtual channel credit packet 22 for a particular virtual channel, the transmitter 10 knows to which virtual channel the credit packet is designated. In other words, the transmitter 10 is now granted permission to send a data packet 20, if available, to the receiver 12 through the virtual channel designated by the credit packet 22. In FIG. 3, the sequence of the flow of the credit packet 22 and the data packet 20 for a single virtual channel is illustrated, with the direction of the arrows beneath the packet information depicting the direction of packet flow between transmitter and receiver. Each data packet 20 from a transmitter can be transmitted only when a credit packet 22 is issued by the receiver 12. FIG. 3 shows the basic flow for multiple transmissions that may take place for each virtual channel.

In accordance with an important aspect of the present invention, a flowchart illustrating the subroutine of the receiver 12 in FIG. 4. In order for the receiver 12 to initially start the process (block 28) for a plurality of virtual channels 16, there must be an operable communication link established (block 30) between the transmitter 10 and the receiver. Once that is done, the receiver 12 spawns a receiver process for a particular virtual channel number N (block 32). The receiver 12 first checks if there is any available buffer for VCN "N" (block 34). If the receiver 12 does not have any buffer available for transmission (block 36), it waits for a predetermined time and rechecks for available buffer until it finds some buffer (block 34). Once available buffer is found (block 36), then the receiver 12 sends a virtual channel credit packet 22 for VCN "N" to the transmitter (block 38).

As noted earlier, the virtual channel credit packet 22 includes the VCN "N" to identify to the transmitter 10 that a transmission is permitted for VCN "N." The receiver 12 next checks to see if it has received a data packet 20 from the transmitter 10 (block 40). If a data packet 20 has not been received, it waits for a predetermined time and rechecks for a data packet 20 (block 40). On the other hand, if the receiver did receive the data packet 20 from the transmitter 10 (block 41), then it loops back to continue checking for available buffer for VCN "N" for the next data packet (block 34). At the same time, the receiver repeats the receiver process for the next VCN, specifically VCN "N+1" (block 42).

The receiver process is repeated until all the VCNs are running (block 42), which brings the receiver process to an end (block 44). Note that since the receiver 12 actually checks for available buffer before issuing a credit packet 22, an acknowledgement packet is not needed in the present invention. After the transmission of the data packet 20, the transmitter 10 is not allowed to send any more data packets until it receives another credit packet 22 bearing its designated VCN.

The flowchart for the subroutine of the transmitter 10 is illustrated in FIG. 5. It is similar to the subroutine of the receiver in that the transmitter 10 does not start the transmitter process (block 46) until there is an operable communication link to the receiver 12 (block 48). When there is an established link, a transmitter process for a particular VCN is spawned (block 50), for example VCN "N". The transmitter 10 similarly verifies whether it has available buffer for transmission of packets for VCN "N" (block 52). If buffer is not available (block 54), it waits for a predetermined time and rechecks the buffer until there is available buffer for transmission (block 52).

In contrast, if there is available buffer (block 54), the transmitter 10 next looks for the virtual channel credit packet 22 with its assigned VCN "N" from the receiver 12 (block 56). If a credit packet 22 can not be found, the transmitter waits for a predetermined time and rechecks for the credit packet 22 for that particular virtual channel with VCN "N" (block 56). If there is a credit packet 22, it checks to determine if it has any data packets 20 for transmission (block 58). The transmitter again waits for a predetermined time and keeps checking for data packets 20 if there is no data packet for transmission (block 58). However, if there is a data packet 20, with the VCN "N" as described earlier, it will accordingly be transmitted to the receiver 12 (block 60). After the transmission of the data packet 20 for VCN "N," the transmitter 10 loops back to continue checking for an available buffer for VCN "N" (block 52). However, it also repeat the transmitter process for the next VCN or VCN "N+1" until all the VCNs are running (block 62). When all the VCNs are running, the transmitter process will exit the subroutine (block 64).

From the foregoing description, it should be understood that an improved method and system for transmitting data between at least one receiver operatively connected to at least one transmitter via at least one high-speed link with a plurality of virtual channels has been shown and described which has many desirable attributes and advantages. The method and system allow the transmitter 10 to send data packets 20 to the receiver 12 only when the receiver is ready and has the available resources to accept the data packets. In addition, by using a data packet 20 and a credit packet 22 with a unique VCN 24 that is specifically assigned to each virtual channel, the present invention is able to avoid the need for an acknowledgement packet, resulting in a more efficient use of bandwidth.

While various embodiments of the present invention have been shown and described, it should be understood that other modifications, substitutions and alternatives are apparent to one of ordinary skill in the art. Such modifications, substitutions and alternatives can be made without departing from the spirit and scope of the invention, which should be determined from the appended claims.

Various features of the invention are set forth in the appended claims.

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WHAT IS CLAIMS IS:

1. A method for transmitting data between at least one receiver operatively connected to at least one transmitter via at least one high-speed link having a plurality of virtual channels, the method comprising the steps of:

the receiver sending a virtual channel credit packet for a particular virtual channel to the transmitter, said credit packet being indicative that said receiver is available to receive data and having a unique virtual channel number assigned to said particular virtual channel thereto;

the transmitter responding to said virtual channel credit packet including transmitting data to the receiver if data is available; and,

the receiver receiving said data transmitted from the transmitter.

2. The method according to claim 1 wherein said virtual channel credit packet is sent when the receiver has the available resources to receive transmission data from the transmitter for said particular virtual channel, and is ready to do so.

3. The method according to claim 1 wherein said data includes said unique virtual channel number assigned to said particular virtual channel.

4. The method according to claim 1 further comprising the steps of repeating the process for the next virtual channel number until all virtual channels are running.

5. The method according to claim 1 wherein prior to said step of the receiver sending a virtual channel credit packet, further comprising the steps of:

the receiver checking for available buffer for transmission;

the receiver waiting for a predetermined time if no buffer is available; and,

the receiver sending said virtual channel credit packet for said specific virtual channel once buffer is available.

6. The method according to claim 5 wherein said step of the receiver waiting for a predetermined time further comprising the step of the receiver repeating said step of the receiver checking for available buffer step until a buffer is available.

7. The method according to claim 1 wherein said step of the transmitter responding to said virtual channel credit packet further comprising the steps of:

the transmitter checking for available buffer for said specific virtual channel;

the transmitter waiting for a predetermined time if no buffer is available; and,

the transmitter looking for said virtual channel credit packet from the receiver if a buffer is available.

8. The method according to claim 7 wherein said step of the transmitter waiting further comprising the step of the transmitter repeating said

step of the transmitter checking for an available buffer until a buffer is available.

9. The method according to claim 7 wherein said step of the transmitter looking for said virtual channel credit packet further comprising the steps of:

the transmitter waiting for a predetermined time if said virtual channel credit packet is not found; and,

the transmitter checking for available data for transmission if said virtual channel credit packet is found.

10. The method according to claim 9 wherein said step of the transmitter waiting further comprising the step of the transmitter repeating said step of the transmitter looking for said virtual channel credit packet until said virtual channel credit packet is found.

11. The method according to claim 9 wherein said step of the transmitter checking for available data further comprising the steps of:

the transmitter waiting for a predetermined time if no data is available; and,

the transmitter sending said data if data is available.

12. The method according to claim 11 wherein said step of the receiver waiting further comprising the step of the receiver repeating step of receiver checking for available data until data is available for transmission.

13. The method according to claim 11 wherein said step of the transmitter sending said data further comprising the step of the transmitter repeating the method according to claim 1 for the next virtual channel credit number.

14. The method according to claim 1 wherein said step of the receiver accepting said data further comprising the steps of:

the receiver checking if said data has been received from the transmitter;

the receiver waiting for a predetermined time if said data has not been received; and,

the receiver repeating the method according to claim 1 for the next virtual channel number if said data has been received.

15. The method according to claim 14 wherein said step of the receiver waiting further comprising the step of the receiver repeating said step of the receiver checking until said data has been received from the transmitter.

16. A system for transmitting data packets between at least one receiver operatively connected to at least one transmitter via at least one high-speed link having a plurality of virtual channels, said system comprising:

means for sending a virtual channel credit packet for a particular virtual channel to the transmitter, said credit packet being indicative that said receiver is available to receive data packet;

means for responding to said virtual channel credit packet and transmitting at least one data packet to said credit packet sending means;

means for accepting said at least one data packet from said data packet transmitting means; and,

said virtual channel credit packet having a unique virtual channel number assigned to said particular virtual channel.

17. A system for transmitting data packets between at least one receiver operatively connected to at least one transmitter via at least one high-speed link having a plurality of virtual channels, said system comprising:

the receiver being adapted to send a virtual channel credit packet for a particular virtual channel to the transmitter, said credit packet being indicative that said receiver is available to receive data packets;

the transmitter being adapted to respond to said virtual channel credit packet and transmit at least one data packet to the receiver;

the receiver being adapted to accept said at least one data packet transmitted from the transmitter; and,

said virtual channel credit packet having a unique virtual channel number assigned to said particular virtual channel.

18. A system according to claim 17 wherein said credit packet is further indicative of the receiver having an available buffer of sufficient capacity to receive a data packet from the transmitter.

ABSTRACT OF THE DISCLOSURE

METHOD AND SYSTEM FOR TRANSMITTING DATA BETWEEN A RECEIVER AND A TRANSMITTER

A method and system for transmitting data between at least one receiver operatively connected to at least one transmitter, and more particularly to a method and a system for permissible transmission via at least one high-speed link having a plurality of virtual channels. The method includes the receiver sending a virtual channel credit packet for a particular virtual channel to the transmitter, the credit packet being indicative that the receiver is available to receive data and having a unique virtual channel number assigned to said particular virtual channel thereto. The transmitter responds to the virtual channel credit packet, which includes transmitting data to the receiver if data is available. The receiver receives the data transmitted from the transmitter.

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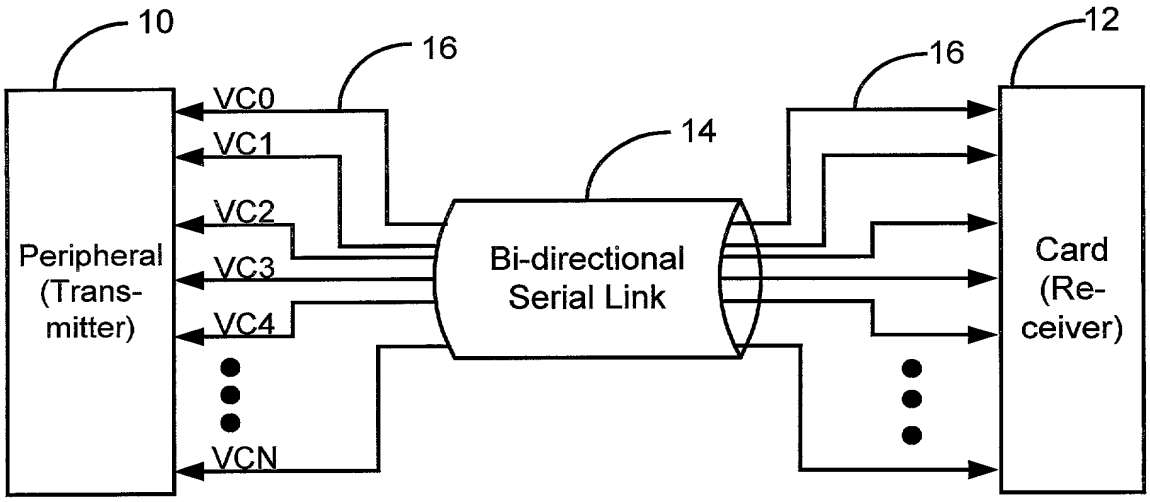

FIG. 1

CONTROL CHARACTERS

26

P 1 0 0	FLOW CONTROL CHARACTER (FCC)
P 1 0 1	END OF HEADER (EOH)
P 1 1 0	END OF PACKET (EOP)
P 1 1 1	ESCAPE (ESC)

DATA PACKET FORMAT

20

3 bits	0 to 65,536 bytes	3 bits	0 to 65,536 bytes	1 byte
EOP	Data	EOH	Header	VCN

24

CREDIT PACKET FORMAT

22

3 bits	3 bits	8 bits
ESC	EOH	VCN

24

FIG. 2

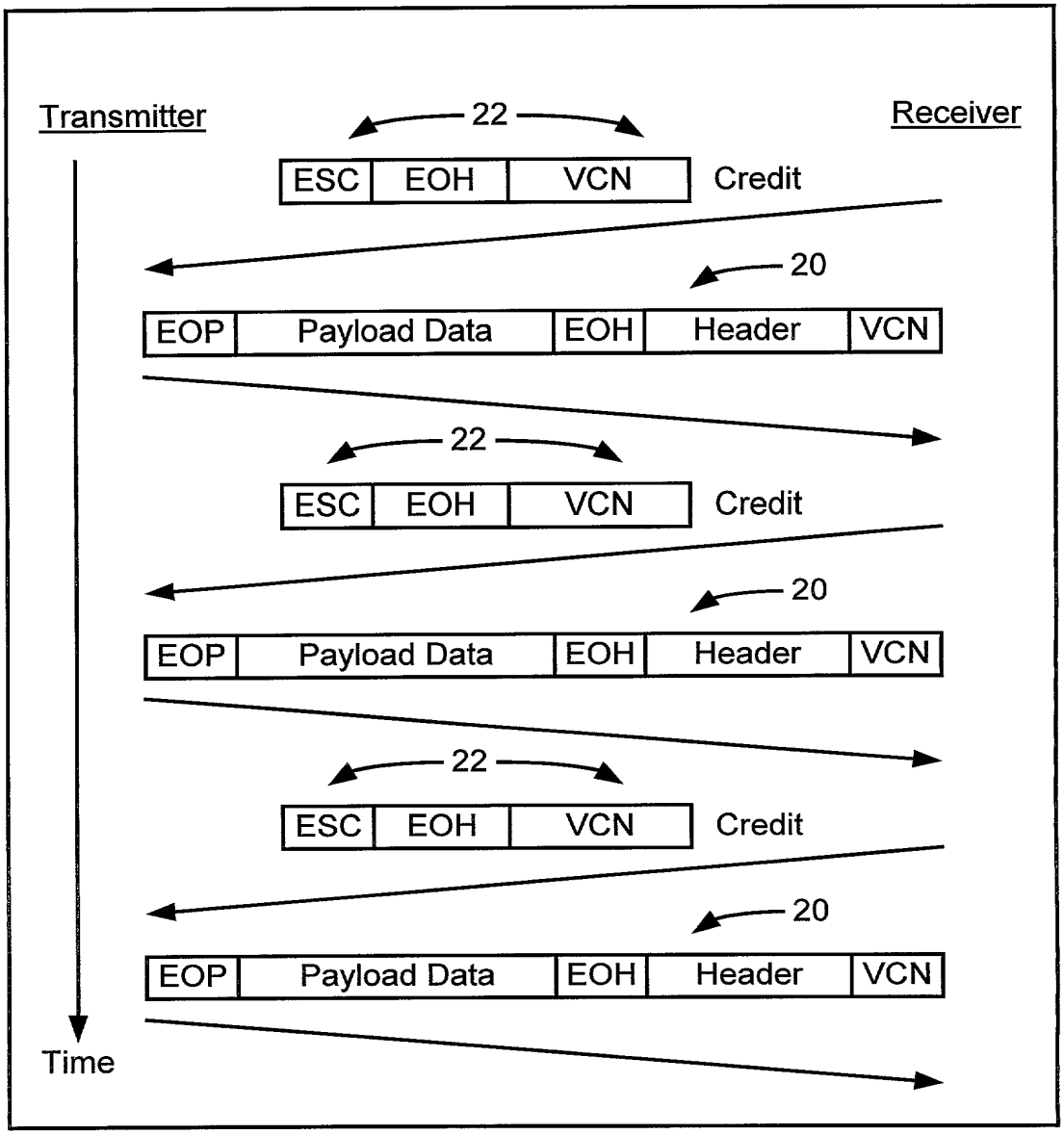
Transmitter
Receiver
22
ESC
EOH
VCN
Credit
20
EOP
Payload Data
EOH
Header
VCN
22
ESC
EOH
VCN
Credit
20
EOP
Payload Data
EOH
Header
VCN
22
ESC
EOH
VCN
Credit
20
EOP
Payload Data
EOH
Header
VCN
Time

FIG. 3

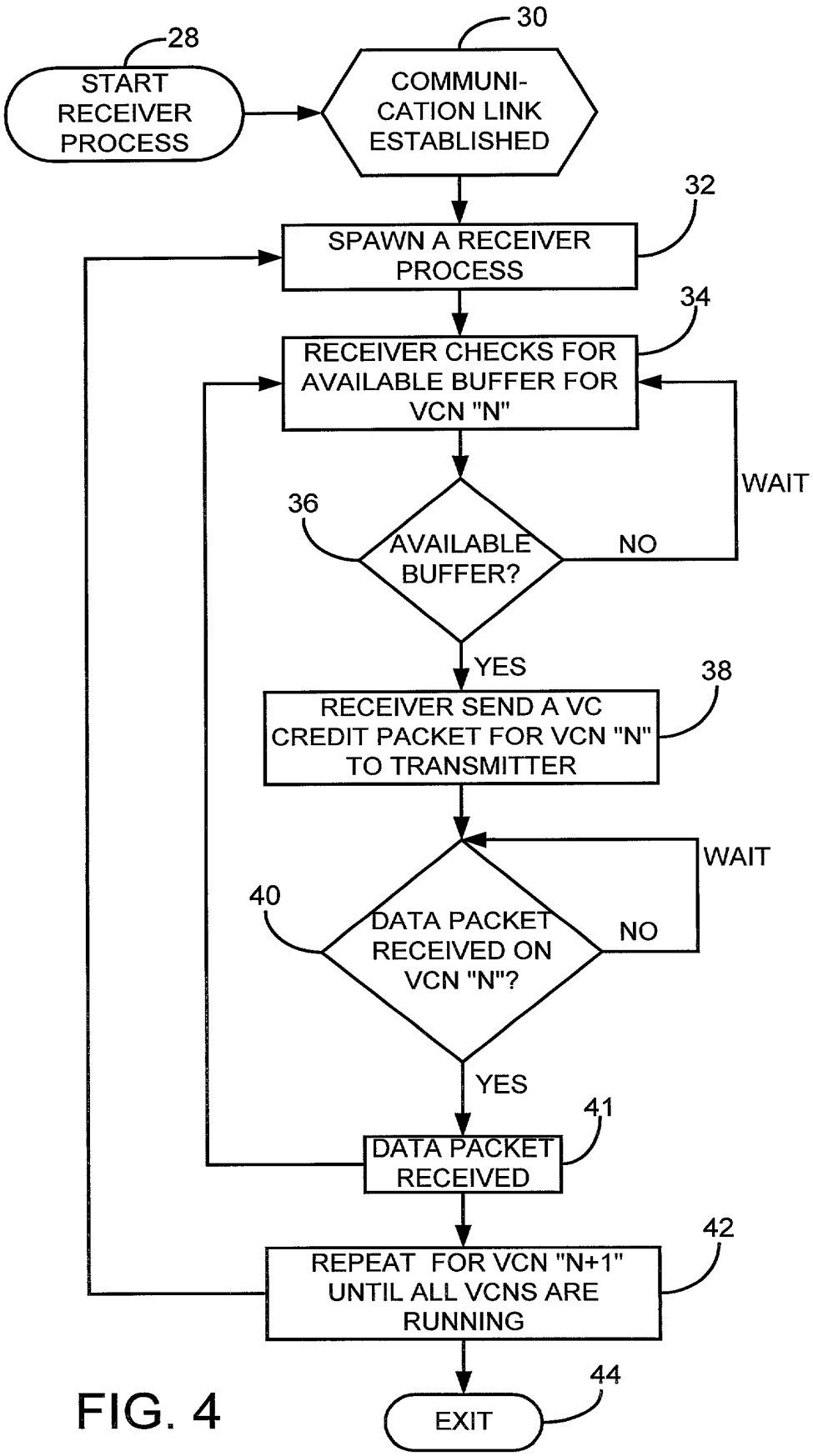
28
START RECEIVER PROCESS
30
COMMUNI-CATION LINK ESTABLISHED
32
SPAWN A RECEIVER PROCESS
34
RECEIVER CHECKS FOR AVAILABLE BUFFER FOR VCN "N"
36
AVAILABLE BUFFER?
NO
WAIT
YES
38
RECEIVER SEND A VC CREDIT PACKET FOR VCN "N" TO TRANSMITTER
40
DATA PACKET RECEIVED ON VCN "N"?
NO
WAIT
YES
41
DATA PACKET RECEIVED
42
REPEAT FOR VCN "N+1" UNTIL ALL VCNS ARE RUNNING
44
EXIT

FIG. 4

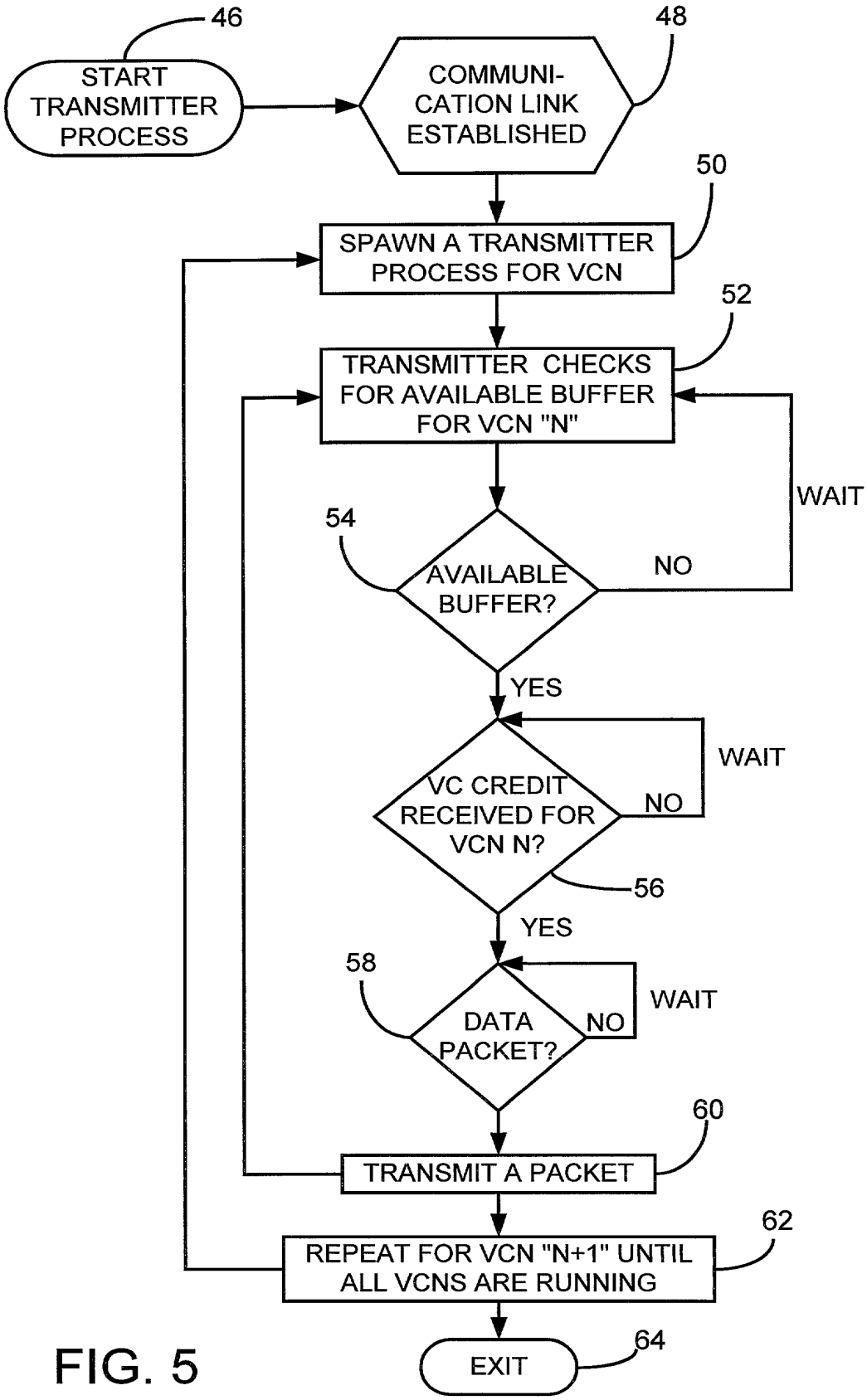
46
START TRANSMITTER PROCESS
48
COMMUNI-CATION LINK ESTABLISHED
50
SPAWN A TRANSMITTER PROCESS FOR VCN
52
TRANSMITTER CHECKS FOR AVAILABLE BUFFER FOR VCN "N"
WAIT
54
AVAILABLE BUFFER?
NO
YES
WAIT
VC CREDIT RECEIVED FOR VCN N?
NO
56
YES
58
DATA PACKET?
NO
WAIT
60
TRANSMIT A PACKET
62
REPEAT FOR VCN "N+1" UNTIL ALL VCNS ARE RUNNING
64
EXIT

FIG. 5

PATENT APPLICATION

DECLARATION AND POWER OF ATTORNEY FOR PATENT APPLICATION

ATTORNEY DOCKET NO. 10001011-1

As a below named inventor, I hereby declare that:

My residence/post office address and citizenship are as stated below next to my name;

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

METHOD AND SYSTEM FOR TRANSMITTING DATA BETWEEN A RECEIVER AND A TRANSMITTER

the specification of which is attached hereto unless the following box is checked:

( ) was filed on _____ as US Application Serial No. or PCT International Application Number _____ and was amended on _____ (if applicable).

I hereby state that I have reviewed and understood the contents of the above-identified specification, including the claims, as amended by any amendment(s) referred to above. I acknowledge the duty to disclose all information which is material to patentability as defined in 37 CFR 1.56.

Foreign Application(s) and/or Claim of Foreign Priority

I hereby claim foreign priority benefits under Title 35, United States Code Section 119 of any foreign application(s) for patent or inventor(s) certificate listed below and have also identified below any foreign application for patent or inventor(s) certificate having a filing date before that of the application on which priority is claimed:

COUNTRY	APPLICATION NUMBER	DATE FILED	PRIORITY CLAIMED UNDER 35 U.S.C. 119
			YES. ___ NO. ___
			YES. ___ NO: ___

Provisional Application

I hereby claim the benefit under Title 35, United States Code Section 119(e) of any United States provisional application(s) listed below:

APPLICATION SERIAL NUMBER	FILING DATE

U. S. Priority Claim

I hereby claim the benefit under Title 35, United States Code, Section 120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code Section 112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, Section 1.56(a) which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

APPLICATION SERIAL NUMBER	FILING DATE	STATUS (patented/pending/abandoned)

POWER OF ATTORNEY:

As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith:

Customer Number 022879

Place Customer Number Bar Code Label here

Send Correspondence to:	Direct Telephone Calls To:
HEWLETT-PACKARD COMPANY Intellectual Property Administration P.O. Box 272400 Fort Collins, Colorado 80528-9599	David M. Mason (408) 447-4046

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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Inventor's Signature Scott Arthur Jones Date 3-23-00

Rev 11/99 (DecPwr) (Use Page Two For Additional Inventor(s) Signature(s))

DECLARATION AND POWER OF ATTORNEY FOR PATENT APPLICATION (continued)

ATTORNEY DOCKET NO. 10001011-1

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Inventor's Signature Thang Vinh Le Date 3/23/00

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Residence: ~~11250 Jaeger Road~~, Auburn, CA 95603 1240 Shirland Tract Rd

Post Office Address: Same as above

Inventor's Signature Fred Joel Anast Date 3/23/00

Full Name of # 5 joint inventor: Citizenship:

Residence:

Post Office Address:

Inventor's Signature Date

Full Name of # 6 joint inventor: Citizenship:

Residence:

Post Office Address:

Inventor's Signature Date

Full Name of # 7 joint inventor: Citizenship:

Residence:

Post Office Address:

Inventor's Signature Date

Full Name of # 8 joint inventor: Citizenship:

Residence:

Post Office Address:

Inventor's Signature Date

Rev 11/99 (DecPwr) (Use Page Two For Additional Inventor(s) Signature(s))